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A comparison of natural and experimental fracture healing in corundum

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Fracture healing experiments in synthetic corundum using supracritical aqueous solutions were performed to contribute to a better understanding of geochemical processes such as Al-mobilisation, the formation of secondary fluid inclusions and hydrothermal crystal growth. It has long been known that corundum (α-Al_2O_3) is soluble in pure water in trace amounts only. In nature, however, there is evidence for significant Al-transport in hydrothermal systems. Aqueous solutions often show high electrolyte concentrations which can be the origin for ligands to form stable Al-complexes. The results of high-P-T experiments suggest that alkali-Al-complexes are formed in significant quantities under crustal P-T conditions in the presence of these electrolytes and may explain Al-transport in natural hydrothermal and metamorphic systems (e.g. Pascal & Anderson, 1989). Evidence for this process is provided by healed fracture planes in natural rubies and sapphires containing secondary fluid inclusions. These are referred to as healing feathers or fingerprints (Hughes 1997). When present, cracks in rubies and sapphires cause undesirable refraction effects and deteriorate the transparency, clarity and stability of the gemstones. This effect makes fracture healing an important economical issue (Hänni 2001).

In the present study, natural and experimentally induced healing textures were compared to evaluate PTXt-parameters this healing process. The experiments were carried out with basic aqueous solutions containing 0.1–2.0m (K,Na)OH at 500-700˚C and 0.5-2.0kbar using cold-seal pressure vessels. Synthetic mirror-finish single crystal white sapphire spheres with a diameter of 2.5mm were heated to 300˚C and quenched

in water to create fractures. The spheres were then sealed in gold capsules with up to 200μl of solution. By using solution only, the spheres' interior was healed but the fractures on the outside were opened wider. Adding 0.005–0.020g of γ-Al_2O_3 caused a complete healing to the surface. Healed fractures from experiments at 600˚C and 2.0 kbar with 1.0m KOH solutions show healing feathers very similar to those found in natural heat-treated rubies. These typically contain 2-phase fluid fluid-gas inclusions. By comparison, 0.1m (K,Na)OH solutions and runtimes up to 238h did not produce fracture healing because of too low Al-mobility. At 600˚C, 2.0 kbar and 2.0m solutions no healing was observed after 24h but after 72h complete healing was found.

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